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COMPLETE SPECIFICATION

Glass Compositions

We, PITTSBURGH PLATE GLASS COMPANY, a corporation organised under the laws of the State of Pennsylvania, United States of America, of One Gateway Center, Pittsburgh 22, State of Pennsylvania, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a novel glass and it has particular relation to a glass useful as the minor segment in a multifocal ophthalmic lens.

A multifocal lens is formed of a major lens segment having a minor lens segment adhered in a recessed portion of the major segment. The major lens segment may be made of crown glass or other glass which is highly refined and free from seed, striae and other imperfections which would impair the optical properties of the lens. One example of a crown glass is an alkali lime silicate glass.

The minor segment is usually made from highly refined glasses known as barium, lead, barium flint or barium crown glasses. The minor segment glass has a higher index of refraction than the major segment and it is the portion of the multifocal lens used for reading. The glasses of the major and minor segments preferably have substantially the same coefficient of thermal expansion. The barium type glasses usually have a slightly lower softening point than the crown glasses, and the flint glasses usually have a softening point considerably lower than the crown glasses.

In the manufacture of a multifocal lens, the minor segment is fused to the major segment. One procedure involves polishing a convex, spherical curve on the minor segment and a concave, spherically curved recess in the major segment and placing the minor segment glass in the recess. The major and minor segments are then sent through a special furnace to accomplish fusion of the segments. Many possible defects make it difficult to obtain high yields of satisfactory multifocal lens blanks. One defect is a tendency for numerous minute gas bubbles to form at the interface of

this fusion during the sealing or fusing of the two glasses. The reason for the formation of these bubbles is not definitely known. Some of the bubbles may be caused by entrapment of air at the interface during fusion.

Another method of making a multifocal fusion which is designed to accomplish this fusion free from bubbles involves placing a ground and polished minor segment lens blank in a mold and pouring the major segment glass while molten into the mold and across the exposed face of the minor segment in a manner such that the advancing molten glass sweeps any air or gases before it as it passes over the face of the minor segment and fuses to it. This method entails the use of a minor segment glass having a much higher softening point, for example 100 to 150 or more °F. higher than that of the major segment glasses. Such glasses are not readily available.

The present invention is concerned with providing a glass for the minor segment which has a relatively high softening point, i.e. from 1382° F. to 1475° F., an index of refraction n_d between 1.57 and 1.67, a high reciprocal dispersion, and a coefficient of expansion compatible with that of the major segment glass. The softening point of the glass is that temperature at which the \log_{10} of the viscosity of the glass in poises is 7.6.

In accordance with the invention, a glass is provided, particularly adapted for use as the minor segment in a multifocal ophthalmic lens, comprising by weight 35 to 52 per cent of SiO_2 , 6 to 12 per cent of one or more alkali metal oxides, 28 to 34 per cent of barium oxide, 2 to 15 per cent of ZrO_2 , and 5 to 15 per cent of oxides selected from the group consisting of CaO , ZrO , PbO , CdO and SrO , but preferably not exceeding 10% of any one thereof. This glass may also include up to 5% TiO_2 , and also may include 0 to 5 per cent Al_2O_3 , 0 to 1.5 per cent fluorine and up to 2 per cent of one or more fining agents.

Various glasses in accordance with the invention have been prepared and have the calculated compositions and properties set forth below.

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Component	Composition														Preferred Range
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
SiO ₂	43.9	43.6	43.6	43.6	41.6	44.3	49.9	43.9	38.7	38.7	38.7	36.7	38.7	35.5	35-52
BaO	29.5	30.5	29.5	30.5	30.5	29.8	28.1	29.6	29.4	30.4	28.4	28.4	30.4	30.3	28-34
Na ₂ O	5.5	5.8	5.8	5.8	5.8	4.5	—	5.1	8.3	8.3	8.8	8.3	8.3	8.3	0-12
K ₂ O	3.6	3.0	3.2	3.0	3.0	3.7	7.8	3.7	—	.5	—	.5	.5	.3	0-10
CaO	3.5	5.5	5.5	—	3.5	3.6	5.5	6.3	—	—	2.0	5.6	5.6	—	0-10
ZnO	3.4	3.4	3.4	8.9	5.4	3.4	5.1	—	—	—	2.0	—	—	—	0-10
PbO	2.0	—	—	—	—	2.0	—	2.0	6.9	6.9	4.9	3.3	1.3	7.0	0-10
ZrO ₂	7.0	5.9	6.9	5.9	5.9	7.0	2.9	7.0	10.9	10.9	12.9	10.9	10.9	10.9	2-15
TiO ₂	1.1	1.7	1.0	1.7	1.7	1.1	—	1.1	4.7	3.7	3.7	3.7	3.7	3.7	0-5
As ₂ O ₃	—	.6	.6	.6	.6	.6	—	—	.6	.6	.6	.6	.6	—	0-2
SnO ₂	.6	—	—	—	—	—	.6	1.3	—	—	—	—	—	1.0	0-2
F ₂	—	—	.5	—	—	—	1.0	—	.5	—	—	—	—	—	0-1.5
Al ₂ O ₃	—	—	—	—	2.0	—	—	—	—	—	—	—	—	3.0	0-5
Index of Refraction N _D	1.617	1.618	1.613	1.614	1.618	1.616	1.590	1.620	1.659	1.655	1.656	1.655	1.645	1.660	1.57-1.67
Coeff. of expansion × 10 ⁻⁶ per °C. Between 25 °C. and 300 °C.	9.0	9.2	9.0	8.6	8.7	8.5	8.5	8.9	8.5	8.8	8.5	8.6	8.6	8.4	7.0-10.0
Softening point °F. Temp. at which the log of the vis. in poises is 10 ^{7.0}	1392	1385	1385	1385	1395	1422	1430	1406	1396	1403	1421	1444	1445	1437	1382-1475
Reciprocal Dispersion $\frac{N_D - 1}{N_D - N_F}$	49.8	50.7	51.6	50.2	50.1	50.5	54.6	49.0	42.4	42.3	44.2	45.2	46.1	42.6	40-56

The amounts of the various ingredients may vary. The ranges set forth above describe approximate limitations which these variations may take and remain within the scope and bounds of the invention. For example, if lower than 35 per cent by weight of SiO_2 is employed in the composition, it tends to make the glass chemically unstable, whereas amounts higher than 52 per cent by weight of SiO_2 make it increasingly difficult to achieve a high index of refraction.

The total of the alkali metal oxides, Na_2O , K_2O and others, is maintained between 6 and 12 per cent by weight. A minimum amount of alkali metal oxide is required to achieve the desired coefficient of expansion, but an excess is to be avoided for it has a deleterious effect on the chemical durability of the glass.

A relatively large amount of barium oxide is desired to achieve the high index of refraction but too much barium oxide causes the glass to devitrify. Calcium oxide, zinc oxide and lead oxide are present to provide the required properties and prevent devitrification. Cadmium oxide and strontium oxide may also be used for this purpose. Any one or combination of these oxides in an amount between 5 to 15 per cent by weight is suitable.

Zirconium dioxide is necessary in the glass to produce a glass having a high softening point. However, an excess of zirconium dioxide acts to undesirably reduce the coefficient of expansion of the glass. Titanium dioxide is added to the glass to control the refractive index. Its use is restricted to about 5 per cent because it lowers the reciprocal dispersion unduly.

Approximately 95 or more per cent by weight of the glass which is the subject of this invention is comprised of SiO_2 , BaO , ZrO_2 , alkali metal oxides and stabilizing bivalent metal oxides such as CaO , ZnO and PbO . The remaining approximately 5 per cent or less by weight of the glass may be made up of TiO_2 , fining agents, melting aids and other materials such as colorants which may affect the transmission, absorption or other properties of the glass without unduly lowering its softening point or harmfully affecting its desirable optical properties.

For example, fluorine may be present to act as an aid in founding the glass at high temperatures. Its use is restricted to less than about 1.5 per cent by weight because objectionable opalescence forms in the glass due to precipitation of fluoride crystals in the body of the glass. Aluminum oxide may also be added to the composition to help obtain a high softening point. Its use is limited to about 5 per cent by weight because higher amounts cause the glass to devitrify. Small amounts of boric oxide are permitted, however, amounts in excess of 1 per cent by weight make it difficult to produce a glass

having a high softening point as well as other desirable properties.

The oxides of antimony and arsenic are added as conventional fining agents and other oxides or other compounds which act by themselves or collectively as fining agents may be employed in the practice of the invention.

The formulation of the present glass provides a minor segment glass which has an index of refraction between 1.57 and 1.67, a coefficient of expansion between 7.0 to 10.0×10^{-4} per $^{\circ}\text{C}$. between 25°C . and 300°C . and a softening point high enough to enable it to be fused to a molten gob of a major segment glass without deformation of the minor segment. Major segment glasses which are suitable for use in the above described method of making multifocal lenses should have a coefficient of expansion between about 7 to 10.0×10^{-4} per $^{\circ}\text{C}$. between 0°C . and 300°C ., an index of refraction of 1.5232 or thereabouts, and a softening point below 1382°F . and preferably below 1300°F .

When the molten gob of major segment glass is poured or pressed into fusing contact with the novel minor segment glass of this invention, it is desired that the softening point of the particular segment glass be about 100°F . or more above the softening point of the major segment glass to prevent deformation of the minor segment.

What we claim is:—

1. A glass, particularly adapted for use as the minor segment in a multifocal ophthalmic lens, comprising by weight 35 to 52 per cent of SiO_2 , 6 to 12 per cent of one or more alkali metal oxides, 28 to 34 per cent of barium oxide, 2 to 15 per cent of ZrO_2 , and 5 to 15 per cent of oxides selected from the group consisting of CaO , ZrO , PbO , CdO and SrO , but preferably not exceeding 10% of any one thereof.

2. A glass according to claim 1, including up to 5 per cent TiO_2 .

3. A glass according to claim 1 or 2, including 0 to 5 per cent Al_2O_3 , 0 to 1.5 per cent fluorine and 0 to 2 per cent of one or more fining agents.

4. A glass according to any of claims 1 to 3, having an index of refraction N_D between 1.57 and 1.67, a softening point above 1382°F . and a coefficient of thermal expansion approximating 7.0 to 10.0×10^{-4} per $^{\circ}\text{C}$. between 25°C . and 300°C .

5. A glass, particularly adapted for use as the minor segment in a multifocal ophthalmic lens, substantially as hereinbefore described.

6. A multifocal lens comprising a minor segment and a major segment, the minor segment being composed of a glass according to any of claims 1 to 5, and the major segment being a glass having a softening point at least about 100°F . lower than the softening point of the minor segment glass, and preferably having a coefficient of expansion within a

compatible with that of the minor segment
glass.

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